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Baroclinic stabilization effect of the Atlantic-Arctic water exchange simulated by the eddy-permitting ocean model and global atmosphere-ocean model

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Numerical experiments were performed with the global atmosphere-ocean model INMCM5 (for version of the international project CMIP6, resolution for atmosphere is 2°x1.5°, 21 level) and with the three-dimensional, free surface, sigma coordinate eddy-permitting ocean circulation model for Atlantic (from 30°S) – Arctic and Bering sea domain (0.25 degrees resolution, Institute of Numerical Mathematics Ocean Model or INMOM). Spatial resolution of the INMCM5 oceanic component is 0.5°x0.25°. Both models have 40 s-levels in ocean. Previously, the simulations were carried out for INMCM5 to generate climatic system stable state. Then model was run for 180 years. In the experiment with INMOM, CORE-II data for 1948-2009 were used.

As the goal for comparing results of two these numerical models, we selected evolution of the density and velocity anomalies in the 0-300m active ocean layer near Fram Strait in the Greenland Sea, where oceanic cyclonic circulation influences Atlantic-Arctic water exchange. Anomalies were count without climatic seasonal cycle for time scales smaller than 30 years. We use Singular Value Decomposition analysis (SVD) for density-velocity anomalies with time lag from minus one to six months. Both models perform identical stable physical result. They reveal that changes of heat and salt transports by West Spitsbergen and East Greenland currents, caused by atmospheric forcing, produce the baroclinic modes of velocity anomalies in 0–300m layer, thereby stabilizing ocean response on the atmospheric forcing, which stimulates keeping water exchange between the North Atlantic and Arctic Ocean at the certain climatological level.

The first SVD-mode of density-velocity anomalies is responsible for the cyclonic circulation variability. The second and third SVD-modes stabilize existing ocean circulation by the anticyclonic vorticity generation. The second and third SVD-modes give 35% of the input to the total dispersion of density anomalies and 16-18% of the input to the total dispersion of velocity anomalies for numerical results as in INMCM5 so in INMOM models. Input to the total dispersion of velocity anomalies for the first SVD-mode is equal to 50% for INMCM5 and only 19% for INMOM.

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